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Streamflow Records from the San Dimas Experimental Forest, 1939 - 1959

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ABSTRACT: Seventeen streamgaging stations to measure the performance of brush-covered watersheds were established on the San Dimas Experimental Forest in southern California. Hydrographs covering 314 station-years of record have been summarized. Mean daily streamflow tables, flood peak tables, and supplemental watershed data have been microfilmed. These data are available to workers who are interested in studying watershed hydrology.

More than 300 station-years of streamflow records from brush-covered mountains in southern California are now available for use by land managers and hydrologists. These data, covering the period 1939 through 1959, were collected from experimental watersheds on the San Dimas Experimental Forest,[1] near Glendora, California. They were compiled jointly by the California Department of Water Resources and the Pacific Southwest Station.[2]

The San Dimas Experimental Forest lies on the southern slopes of the San Gabriel Mountains. To determine how experimental watersheds there function, streamgaging stations were built in each of the 17 watersheds -- 10 in San Dimas Canyon and 7 in Big Dalton Canyon (fig. 1). The watersheds ranged in size from 37 to 8,410 acres.

A wildfire in July 1960 stripped most of the vegetation from the watersheds and destroyed many of the gaging facilities. Therefore streamflow records for the post-fire years are not included in the available data.

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[1]Maintained by the U.S. Forest Service in cooperation with the California Division of Forestry.

[2]Although the authors have been most recently connected with these records, they are merely the last of many individuals who have assisted with this work. This assistance is gratefully acknowledged.

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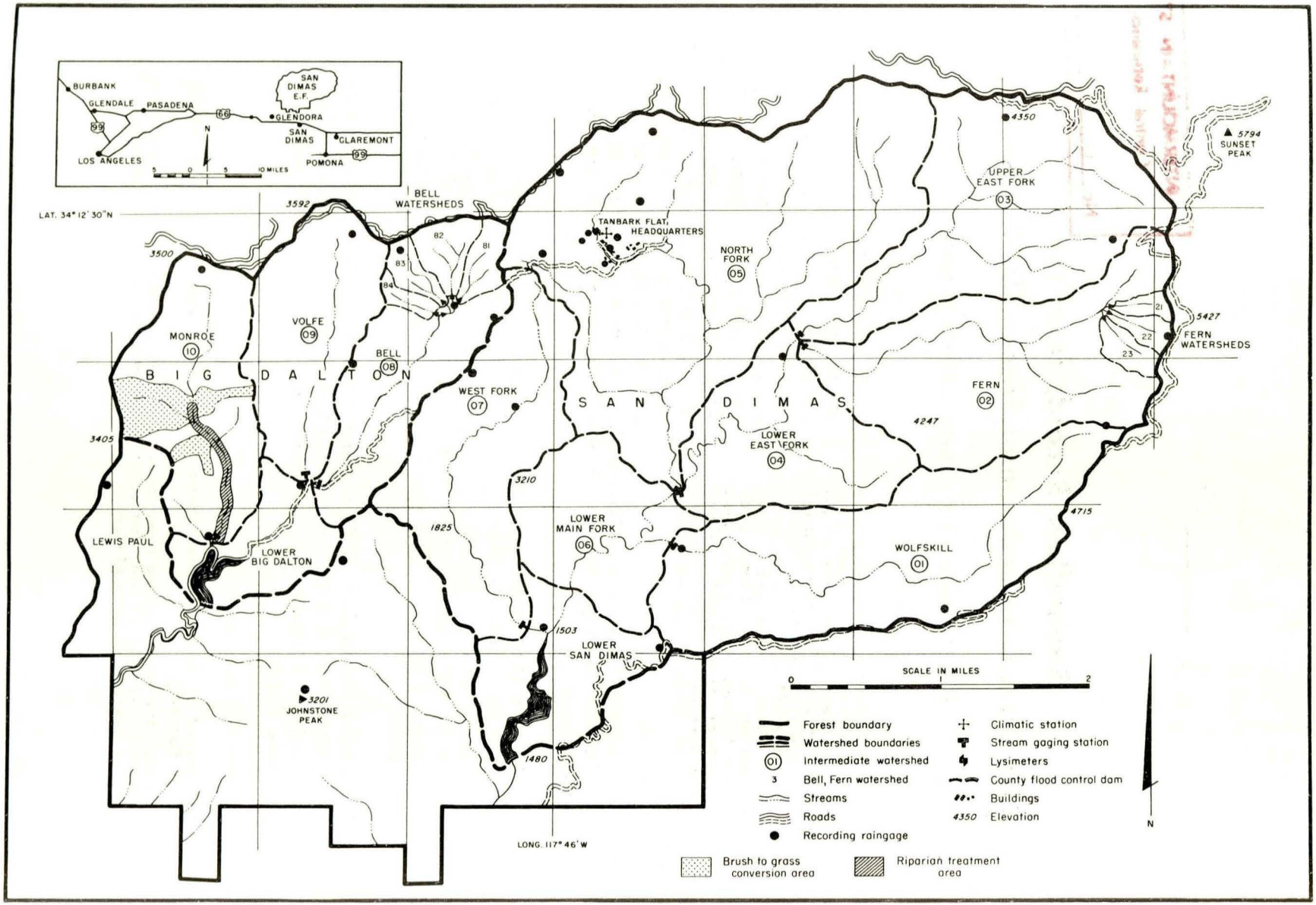

Figure 1.--San Dimas Experimental Forest

Table 1. --Acreage on the San Dimas Experimental Forest, by slope gradient and soil depth classes

Steepness of slope[1]	Dominant depth of soil					
	Very shallow (under 1 foot)	Shallow (1 to 2 feet)	Medium (2 to 3 feet)	Deep (3 to 4 feet)	Deep (over 4 feet)	All depths
	Percent					
Moderate to steep:						
Under 40	--	2	3	1	(2/)	7
40-55	(2/)	2	3	1	(2/)	7
Steep:						
55-70	4	23	12	3	(2/)	42
Extremely steep:						
Over 70	34	9	1	--	--	44
All gradients	38	36	19	5	(2/)	100

Source: Bentley (1961).

[1] Dominant slope gradient, in percent.

[2] Less than 1 percent of the acreage.

VEGETATION AND SOILS

The experimental forest is typical of southern California brushland watersheds (Hill 1963). The vegetation consists of two major plant formations--chaparral and woodland chaparral. Important chaparral cover types include chamise-chaparral, sage-buckwheat, and scrub oak. In the woodland chaparral the important types include live oak-chaparral, live oak-woodland, and big cone Douglas-fir.

The slopes of the watersheds (table 1) have immature residual soils that are generally less than 3 feet deep. They developed from highly weathered and fractured bedrock (Bentley 1961; Crawford 1962). The faulted and fractured condition of the bedrock influences the hydrology of the watersheds (Storey 1948). Bedrock formations belong to an igneous-metamorphic complex. The most common types of rocks are diorites, schists, gneisses, granites, and granodiorites. They are heavily intruded by dikes of other more weather resistant rocks.

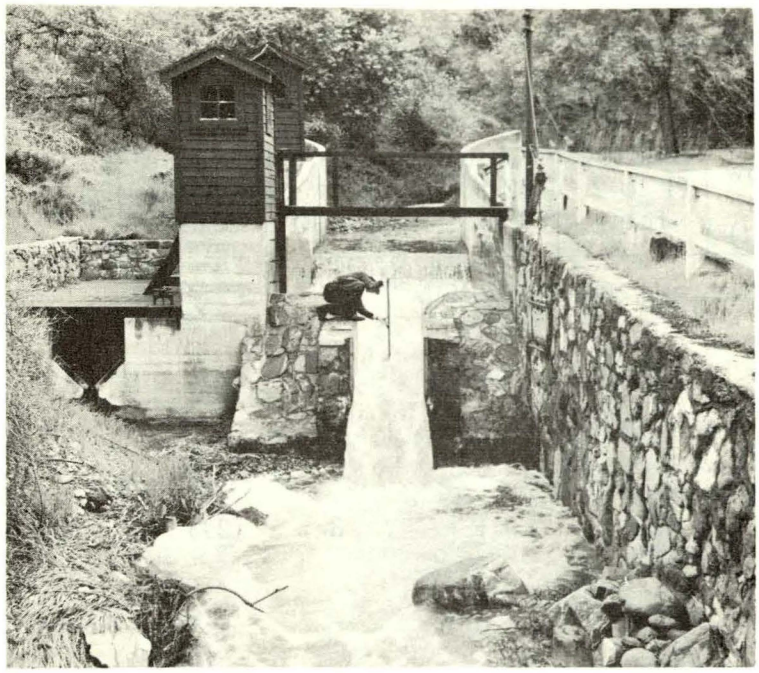

Figure 2.--Typical San Dimas flume showing 90° V-notch weir, and 3-foot and 10-foot rectangular sections.

CLIMATE

The area has a Mediterranean climate. Summers are often without measurable rainfall; 77 percent of the rain falls between December and March when high intensity storms are common. Precipitation averaged about 27 inches per year from 1933 to 1958 (Reiman and Hamilton 1959). Nearly all precipitation occurs as rain, but snow occasionally falls at higher elevations.[3]

Records for the 27 years show that monthly temperatures ranged between 47° F. in January and 72° F. in July and August (Reiman 1959). The average annual temperature was 57.9° F. and the average annual evaporation was 64 inches (Reiman 1959).

STREAMGAGES

Streamflow from each watershed was measured by one of three weirs. Flows less than 6 c.f.s. were measured by a 90° V-notch weir. Intermediate discharges up to 150 c.f.s. were measured in 3-foot and 4-foot rectangular San Dimas flumes (Wilm et al. 1938). Higher flows were measured in 8-foot and 10-foot San Dimas flumes (fig. 2).

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[3]Computer programs are being developed to analyze amounts, intensities, and frequencies of precipitation events for all available gages in San Dimas Experimental Forest.

DATA REDUCTION

Two different computers processed the data. Sixty-three station years were computed by a Bendix G-15 of the California Department of Water Resources (table 2). Input for this computer was that combination of 1/2-hour, 6-hour, 12-hour, and 24-hour readings that best described the hydrograph. The flow for an interval was computed as follows:

$$Q_{1,2} = K\left(\frac{H_1 + H_2}{2}\right)^C \left(t_2 - t_1\right)$$

in which,

$Q_{1,2}$ = the discharge in the interval between two readings of the hydrograph

K = a constant of the rating equation

H = stage at the beginning and end of the period

C = an exponent of the rating equation

t = the time at the beginning and end of the period.

The output included annual tables of mean daily flow, peak discharge, and detailed listings of the volume and rate of flow in each interval read.

The other computer was an IBM 7090 at the University of California at Los Angeles. Input for this computer was every change in slope of the hydrograph. Work included tablulating data by hand for 251 station years, followed by hand keypunching and verifying. A Gerber Model 3B chart reader directly keypunched data for 63 station-years. We found that fewer errors were made when the chart reader system was used than in hand tabulating and keypunching data. The IBM 7090 computed the flow for an interval as follows:

$$Q_{1,2} = \int_{t_1}^{t_2} q\, dt$$

in which, $q = KH^C$ and $H = mt+b$ (of the form $y = mx + b$)

or:

$$Q_{1,2} = \frac{K}{m(C+1)}\left[H_2^{(C+1)} - H_1^{(C+1)}\right]$$

Table 2. --Available streamflow data by hydrologic year and watershed number

Hydrologic year	Watershed Number[1]															
	1	2	3	4	5	6	7	8	9	10	21	22	23	81	82	83	84
1939	CR	KP	CR	CR	CR	CR	--	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1940	CR	KP	CR	CR	CR	CR	--	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1941	CR	CR	CR	CR	CR	CR	CR	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1942	CR	CR	CR	CR	CR	CR	CR	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1943	CR	CR	CR	CR	CR	CR	CR	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1944	CR	CR	CR	CR	CR	CR	CR	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1945	CR	CR	CR	CR	CR	CR	CR	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1946	CR	CR	CR	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1947	CR	--	--	--	--	--	--	DWR	DWR	DWR	--	--	--	KP	--	--	--
1948	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1949	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1950	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1951	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	--
1952	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1953	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	--	KP	KP	KP	KP	KP
1954	KP	KP	KP	KP	KP	CR	KP	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1955	KP	KP	KP	--	--	--	--	DWR	DWR	DWR	KP	--	KP	KP	KP	KP	KP
1956	KP	KP	KP	--	--	--	--	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1957	KP	KP	KP	--	--	--	--	DWR	DWR	DWR	KP	KP	KP	KP	KP	KP	KP
1958	CR	CR	CR	--	--	--	--	DWR	DWR	DWR	--	--	--	KP	KP	KP	KP
1959	CR	CR	CR	--	--	--	--	DWR	DWR	DWR	--	--	--	KP	KP	KP	KP

[1]Legend: CR = Chart reader data
KP = Hand tabulated and keypunched
-- = Data missing
DWR = California Dept. of Water Resources method

Table 3.--Example of mean daily streamflow output data

SDEF STREAMFLOW

WATERSHED 1 WOLFSKILL

0. MEANS NO FLOW 0.0000 MEANS FLOW BELOW 4TH DECIMAL

DAILY MEAN FLOW IN CUBIC FT./ SEC. WATER YEAR OCTOBER 1938 THROUGH SEPTEMBER 1939

DATE	OCT.	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.
1	0.6121*	0.7205	0.6204*	0.9367	1.2075	0.7879	0.8541	0.5760	0.5004	0.2498	0.2085	0.1402
2	0.6283*	0.6837	0.6129*	0.9310	1.1481	0.7732	1.1880	0.5847	0.4331	0.2665*	0.2306	0.1512
3	0.6434*	0.6238	0.6110	0.8922	1.6712	0.7815	0.9336	0.5656	0.4089	0.3053	0.2319	0.1781
4	0.6260*	0.6026	0.6032	0.9026	1.7980	0.7792	0.8689	0.5459	0.4438	0.3509*	0.2111	0.1727
5	0.6583	0.6245	0.5942	2.2202*	1.4505	0.7620	0.8115	0.5563	0.4530	0.3797*	0.2035	0.1941
6	0.6960	0.5950	0.5869	1.5845*	1.3963	0.7417	0.7432	0.5995	0.4434	0.3384	0.2260	0.2388
7	0.7091	0.5888	0.5876	1.3212	1.3815	0.7394	0.7251	0.5801	0.4376	0.2889	0.2516	0.2523
8	0.6995	0.5937	0.5919	1.2355*	2.2890	0.7424	0.7135	0.5354	0.4186	0.2603	0.2318	0.2170
9	0.6376	0.6021*	0.5970	1.1052*	1.5968	0.8852	0.7002	0.5121	0.3981	0.2590	0.2041	0.1803
10	0.5978	0.6634*	0.6246	0.9736	1.4287*	1.2108	0.6948	0.5700	0.3951	0.2361	0.1867	0.1671
11	0.5780	0.6654*	0.6828	0.9538	1.2858*	0.8230	0.7013	0.6102	0.3882	0.2169	0.1819	0.2565
12	0.5570	0.6615*	0.6776	0.9139	1.1544*	0.7720	0.7400	0.5913	0.3612	0.2070	0.1633	0.2999
13	0.5938	0.6517	0.6344	0.9113	1.0704*	0.7507	0.7789	0.6212	0.3480	0.2017	0.1591	0.2804
14	0.6644	0.6488*	0.7671	0.8840	1.0392	0.7437	0.7760	0.6477	0.3633	0.2087	0.1806	0.2609
15	0.8655	0.6325*	1.4115*	0.8572	1.0024	0.7253	0.7332	0.6429	0.4060	0.2108	0.1731	0.2128
16	0.7319	0.6109	1.0794*	0.8298	0.9181	0.7117	0.6793	0.6290	0.4261	0.2248	0.1550	0.1873
17	0.6689	0.6079*	0.9506*	0.8020*	0.8769	0.7029	0.6483	0.6169	0.4120	0.2421	0.1528	0.1778
18	0.6258*	0.6060*	2.8154	0.7830	0.8839	0.6879	0.6301	0.6087	0.3626	0.2448*	0.1611	0.1716
19	0.6047	0.6065*	6.3241	0.7789	0.8829	0.6921	0.6191	0.5736	0.3532	0.2399	0.1784	0.1742
20	0.6048	0.6027*	5.1101*	0.7794*	0.8806	0.8271	0.5950	0.5445	0.3604	0.2234	0.1949	0.1868
21	0.5879	0.6018*	2.3308*	2.1646*	0.8549	0.7488	0.6045	0.5329	0.3333	0.2248	0.1651	0.1934
22	0.5754	0.5954*	1.5339*	1.6520*	0.8178	0.7372	0.6349	0.5343	0.3137	0.2226	0.1589	0.1812
23	0.5599	0.5938*	1.4244	1.4482	0.8056	0.7370	0.6690	0.5343	0.3173	0.2107	0.1593	0.1586
24	0.5601	0.5906*	1.3663	1.3344	0.8118	0.7326	0.6641	0.5064	0.3456	0.2075	0.1600	0.6135
25	0.5485	0.5901*	1.2347	1.2345	0.8042	0.7319	0.6823	0.4584	0.3326	0.2085	0.1562	4.2434
26	0.5604	0.5940*	1.1072	1.2360	0.7963	1.1250	0.6611	0.4549	0.3070	0.1892	0.1552	2.7387
27	0.5775	0.5967*	1.0625	1.2074	0.7869	1.5737	0.6114	0.4422	0.2954	0.1917	0.1512	1.2307
28	0.6024	0.6032*	1.0460	1.2251	0.7936	1.2501	0.5965	0.4465	0.2804	0.1973	0.1460	0.7974
29	0.6238	0.6044*	1.0286	1.1699		1.0546	0.6011	0.4408	0.2648	0.2085	0.1467	0.6572
30	0.6721	0.6145*	1.0074	1.3321		0.9661	0.5783	0.4721	0.2514	0.2239	0.1369	0.5702
31	0.6995	-------	0.9743	1.3168		.8958	-------	0.5191	-------	0.2213	0.1346	-------
MEAN	0.6313	0.6192	1.3096	1.1586	1.1369	0.8449	0.7146	0.5501	0.3718	0.2407	0.1792	0.5162
ACFT	38.8177	36.8463	80.5266	71.2403	63.1403	51.9523	42.5205	33.8250	22.1253	14.7988	11.0204	30.7132

TOTAL RUNOFF IN ACRE-FEET 497.5267

THE ABOVE DATA IS ACCURATE TO THREE SIGNIFICANT FIGURES ONLY
ASTERISKS DENOTE RECORDS CONTAINING ESTIMATED FLOW

Table 4. --Example of peak discharge tables

PEAK DISCHARGE

WATERSHED 1 WOLFSKILL

1938-1939

DATE	HOUR	FLOW (CFS)
10-15-38	625	1.1800
12-15-38	112	2.3202
12-19-38	401	15.8055
1- 5-39	1346	8.2615
1-21-39	1216	3.6776
1-30-39	2012	2.2537
2- 3-39	1605	2.2537
2- 8-39	548	3.6209
3- 9-39	2315	2.5397
3-20-39	352	1.0687
3-27-39	1311	2.0303
4- 2-39	602	1.6254
4-13-39	2038	0.8137
5-13-39	2233	0.6504
9-11-39	948	0.3343
9-25-39	1135	8.7375

in which,

$$m = \text{slope of hydrograph trace} = \frac{\Delta H}{\Delta t}.$$

This computer program produced only annual tables of mean daily flow and peak discharge, but more detailed output can be obtained.

A simple linear regression based on 1,130 daily flows showed no significant difference between the Bendix G-15 and the IBM 7090 chart-read computer methods.

DATA AVAILABLE

All annual streamflow tables and peak discharge tables (tables 3, 4) have been microfilmed. Included with these tables are summaries of monthly and annual climatic data (rainfall, evaporation, and temperature) and descriptions of the watersheds, including vegetative cover and soil depth, slope, and geology. The full records may be obtained upon request to the Director, Pacific Southwest Forest and Range Experiment Station, P. O. Box 245, Berkeley, California 94701. Data will be supplied at the expense of the requestor.

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LITERATURE CITED

Bentley, Jay R.
1961. Fitting brush conversion to the San Gabriel Mountains. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 61, 8 pp., illus.

Crawford, James W., Jr.
1962. Soils of the San Dimas Experimental Forest. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 76, 20 pp., illus.

Hill, L. W.
1963. The San Dimas Experimental Forest. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. 25 pp., illus.

Reiman, Lyle F.
1959. Mountain temperatures. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 36, 33 pp., illus.

———
1959. Mountain evaporation. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 35, 14 pp., illus.

———, and Hamilton, Everett L.
1959. Four hundred and sixty storms. U. S. Forest Serv. Pacific SW. Forest & Range Expt. Sta. Misc. Paper 37, 101 pp., illus.

Storey, H. C.
1948. Geology of the San Gabriel Mountains, California, and its relation to water distribution. California Div. Forestry, 19 pp., illus.

Wilm, H. G., Cotton, J. S., and Storey, H. C.
1938. Measurement of debris-laden streamflow with critical-depth flumes. Amer. Soc. Civil Engin. Proc. 63(7): 1259-1275, illus.